TABLE C-2. ACCURACY OF FAA FORECASTS OF NUMBERS OF AIRCRAFT HANDLED BY AIR ROUTE CENTERS (Twelve-year and five-year errors, in percents)

Fiscal Year in Which Forecast Was Made	Air Carriers a/		General Aviation		Total Civilian Aircraft	
	12 Years	5 Years	12 Years	5 Years	12 Years	5 Years
1966	21.9 b/	-3.1	30.4	23.7	24.7	3.0
1967	57.7	30.3	67.1	38.5	61.0	32.2
1968	41.8	25.2	95.5	26.1	60.6	25.4
1969	49.4	28.1	89.9	15.7	64.0	24.7
1970	23.1	11.7	185.3	30.9	74.9	17.2
1971	---	-8.0	---	43.3	---	7.6
1972	---	-5.5	---	43.5	---	10.2
1973	---	-5.8	---	15.4	---	1.3
1974	---	3.1	---	-9.1	---	-1.2
1975	---	4.2	---	-11.2	---	-1.2
1976	---	7.6	---	11.2	---	8.5
1977	---	11.3	---	50.1	---	23.8

SOURCE: CBO from FAA data.

NOTE: Minus sign denotes percentage underestimate; blanks indicate that forecast period is not yet complete.

a. Includes air taxi.

b. The 1966 forecast of air carrier aircraft to be handled 12 years later (1978) turned out to be 21.9 percent too high.

TABLE C-3. ACCURACY OF FAA FORECASTS OF INSTRUMENT OPERATIONS AT AIRPORTS WITH FAA TRAFFIC CONTROL TOWERS (Twelve-year and five-year errors, in percents)

Fiscal Year in Which Forecast Was Made	Air Carrier		General Aviation		All Aircraft	
	12 Years	5 Years	12 Years	5 Years	12 Years	5 Years
1966	N/A	N/A	N/A	N/A	-17.5	0.0
1967	N/A	N/A	N/A	N/A	15.2	22.7
1968	N/A	N/A	N/A	N/A	32.5	15.6
1969	N/A	N/A	N/A	N/A	14.8	-2.1
1970	N/A	N/A	N/A	N/A	20.6	-15.3
1971	---	N/A	---	N/A	---	-16.4
1972	---	-15.7	---	-30.9	---	-20.0
1973	---	-15.6	---	2.5	---	-3.6
1974	---	-5.6	---	-1.7	---	-2.2
1975	---	-6.1	---	-7.8	---	-7.1
1976	---	-6.8	---	16.8	---	4.6
1977	---	9.2	---	43.2	---	22.8

SOURCE: CBO from FAA data.

NOTES: N/A = Not available. Minus sign denotes percentage underestimate; blanks indicate that forecast period is not yet complete.

TABLE C-4. ACCURACY OF FAA FORECASTS OF AVIATION FUEL CONSUMPTION (Twelve-year and five-year errors, in percents)

Fiscal Year in Which Forecast Was Made	Air Carrier		General Aviation						Total Fuel	
			Gasoline		Jet Fuel		All Fuel			
	12 Years	5 Years	12 Years	5 Years	12 Years	5 Years	12 Years	5 Years	12 Years	5 Years
1966	54.3	-6.3	28.3	13.8	-26.0	17.5	-4.7	22.5	47.2	-4.9
1967	77.4	7.7	45.8	35.6	-44.1	-17.9	-7.7	13.5	66.8	8.2
1968	73.0	23.8	60.1	37.5	-43.9	-17.8	-4.8	14.0	63.0	23.0
1969	91.3	32.5	86.0	50.1	-50.0	-27.2	-1.1	15.6	78.3	31.0
1970	129.0	43.5	119.6	68.7	-62.1	-57.8	+0.4	-2.6	109.1	38.6
1971	---	35.2	---	56.3	---	-57.8	---	-9.2	---	30.2
1972	---	34.5	---	43.6	---	-48.8	---	-12.4	---	28.8
1973	---	25.6	---	5.3	---	-35.1	---	-19.5	---	20.0
1974	---	14.3	---	-0.6	---	-31.9	---	-19.2	---	10.2
1975	---	0.6	---	13.2	---	-27.6	---	-12.4	---	-1.1
1976	---	6.7	---	34.2	---	-5.9	---	8.5	---	7.0
1977	---	17.0	---	17.9	---	12.5	---	7.9	---	11.2

SOURCE: CBO from FAA data.

NOTE: Minus sign denotes percentage underestimate; blanks indicate that forecast period is not yet complete.

FAA METHODOLOGY

To help understand the relationship between aviation activity and economic conditions, FAA analysts have developed econometric models of past trends. Such a model is simply a mathematical representation of air traffic and its relationship to those economic variables thought to influence traffic growth. Econometrics is the statistical technique used to quantify the relationships. The most recent published relationships are summarized in Table C-5 and discussed below. Current FAA forecasts are shown in Tables C-6, C-7, and C-8.

ALTERNATIVE EXPLANATIONS OF PAST TRENDS

The plausibility of different assumptions about the relationship between air traffic and economic growth may be tested by simply using models with a different mathematical form.

A Maturity Scenario

One alternative assumption, discussed in Chapter III, is that the influence of rising income on air traffic, rather than remaining constant, is declining over time, as the travel market matures and approaches a saturation point, or plateau. In quantifying such a model, the CBO's statistical analysis finds that it explains past trends quite well--in fact, about as well as the FAA models. 1/ This means that neither the FAA assumptions nor the "maturity scenario" tested here emerges as a better explanation of past trends.

This difficulty in explaining past trends is unfortunate, since alternative models result in very different forecasts of future trends. For example, the maturity models yield a 9 percent smaller workload at air route traffic control centers in 1987 than the FAA models; this difference increases to 14 percent by 1993, and to 29 percent by the turn of the next century (see

---

1. In econometric jargon, CBO estimated logistic (s-shaped) and semi-logarithmic (declining elasticity) models for passenger miles and general aviation aircraft fleet data over the period 1959-1980. CBO also estimated log-linear models as a basis for comparison. R^2 values for all three models were roughly equal (about 0.95). This equality arises in part because all three models reflect smooth time trends in the data, making it impossible to distinguish among them on statistical grounds.

TABLE C-5. SUMMARY OF RECENT FAA FORECASTING MODELS, BY AVIATION ACTIVITY a/

Activity	Model Form	Causal Variables	Elasticity (At mean) a/
Air Carrier Operations			
Revenue passenger miles (RPMs)	Linear	Revenue per passenger mile	-0.64
		Disposable income	1.80
		Investment in transportation	0.26
Total domestic operations	$\frac{\text{RPM} \times 2}{\text{Load factor} \times \text{Average seating capacity} \times \text{Average stage length}}$	N/A	N/A
General Aviation			
Tower workload			
Change in fleet size	Semi Log-linear in differences	GNP	17.00
		Aircraft price	-4.00
		Interest rates	-2.00
		Sales	3.00
		Time	Negative
Itinerate operations	Linear	Fleet size	1.07
		Fuel price	-0.23

(Continued)

TABLE C-5. (Continued)

Activity	Model Form	Causal Variables	Elasticity (At mean) a/
General Aviation			
Tower workload (continued)			
Local operations	Linear	Fleet size	0.21
		Students	1.00
Instrument operations	Linear	Fleet size	1.50
Flight service station workload			
Aircraft contacted	Linear	Itinerant operations	1.10
Pilot briefs	Linear	Fleet size	1.60
		Fuel price	-0.30
VFR flight plans	Linear	Fleet size	0.60
		Fuel price	-0.27
IFR flight plans	Linear	Fleet size	1.60
		Fuel price	-0.21

SOURCE: Congressional Budget Office from FAA Aviation Forecasts (September 1978) and Transportation Research Board, Circular No. 230 (August 1981).

NOTES: Minus sign denotes an inverse relationship between activity and the causal variable. Information reported in this table draws on the most recently published description of FAA models. Details change continuously as the FAA updates its methodology and data analysis.

a. Elasticity is the estimated percentage change in aviation activity that corresponds to each 1 percent change in a causal variable.

TABLE C-6. RECENT FAA FORECASTS OF AIRCRAFT HANDLED BY AIR ROUTE CENTERS
(In millions of dollars)

	Total Aircraft a/			General Aviation			Air Carrier (Including air taxi)		
	1987	1993	2005	1987	1993	2005	1987	1993	2005
FAA Forecast February 1982	34.7	43.4	57.8 b/	12.1	17.1	25.5 b/	18.0	21.7	27.7 b/
FAA Forecast February 1983 c/	34.0 (-2.0)	40.5 (-6.7)	51.5 b/ (-10.9)	11.1 (-8.3)	14.8 (-13.5)	20.9 b/ (-18.0)	18.3 (1.7)	21.1 (-2.8)	26.0 b/ (-6.1)

SOURCE: CBO from FAA data.

NOTE: Actual handles for 1982 were:

Total aircraft = 27.8 million
General aviation = 7.5 million
Air carrier = 16.0 million

a. The difference between total aircraft and the same of general aviation and air carrier reflects military aircraft.

b. Extrapolated by Congressional Budget Office.

c. Numbers in parentheses are the percent changes from the 1982 FAA forecast.

TABLE C-7. RECENT FAA FORECASTS OF INSTRUMENT OPERATIONS AT AIRPORTS WITH FAA TRAFFIC CONTROL SERVICE (In millions)

	Total Aircraft		
	1987	1993	2005
FAA 1982 Forecast	46.2	55.4	74.8
FAA 1983 Forecast a/	44.3 (-4.1)	52.9 (-4.5)	66.6 (-11.0)

SOURCE: CBO from FAA data.

NOTE: Actual operations for 1982 were 31.6 million.

a. Numbers in parentheses are the percent deviation of actual experience from the 1982 FAA forecast.

TABLE C-8. RECENT FAA FORECASTS OF AVIATION FUEL CONSUMPTION
(In billions of gallons)

	Air Carrier			General Aviation			Total Aircraft		
	1987	1993	2005	1987	1993	2005	1987	1993	2005
FAA 1982 Forecast	10.0	11.8	15.4 a/	1.9	2.8	4.1 a/	12.0	14.6	19.5 a/
FAA 1983 Forecast b/	9.4 (-6.0)	11.1 (-5.9)	14.2 a/ (-7.8)	1.9 (--)	2.6 (-7.1)	4.0 a/ (-2.4)	11.3 (-5.8)	13.7 (-6.2)	18.0 a/ (-7.7)

SOURCE: CBO from FAA data.

NOTES: Details may not add to totals because of rounding. Actual handles for 1982 were

Total aircraft = 9.8 million
General aviation = 1.5 million
Air carrier = 8.3 million

a. Extrapolated by Congressional Budget Office.

b. Numbers in parentheses are the percent changes from the 1982 FAA forecast.

Tables C-9, C-10, and C-11). Since there is no reasonable basis on which to elect one forecast over the other, it is essential to subject potential aviation system investments and financing plans to a wide range of sensitivities in underlying traffic assumptions. This analysis is performed for the National Airspace System Plan in Chapters III and IV.

TABLE C-9. ALTERNATIVE FORECASTS OF AIRCRAFT HANDLED AT AIR ROUTE TRAFFIC CONTROL CENTERS (In millions) a/

	Air Carrier (Including air taxi)			General Aviation			Total Aircraft b/		
	1987	1993	2005	1987	1993	2005	1987	1993	2005
FAA Forecast February 1982 (Basis for FAA plan)	18.0	21.7	27.7 c/	12.1	17.1	25.5 c/	34.7	43.4	57.8 c/
FAA Forecast February 1983	18.3 (1.7)	21.1 (-2.8)	26.0 c/ (-6.1)	11.1 (-8.3)	14.8 (-13.5)	20.9 c/ (-18.0)	34.0 (-2.0)	40.5 (-6.7)	51.5 c/ (-10.9)
Forecast Based on Maturity Scenario	17.4 (-3.3)	19.0 (-12.4)	21.4 (-22.7)	9.3 (-23.1)	11.5 (-32.7)	15.1 (-40.8)	31.0 (-10.7)	34.9 (-19.6)	40.9 (-29.2)

SOURCE: CBO from FAA data.

NOTE: The actual numbers of aircraft handled in 1982 was:

Total aircraft = 27.8 million
General aviation = 7.5 million
Air carrier = 16.0 million

a. Numbers in parentheses are the percent changes from the 1982 FAA forecast.
b. The difference between total aircraft and the totals of general aviation and air carrier aircraft represents military aircraft.
c. Extrapolated by Congressional Budget Office.

TABLE C-10. ALTERNATIVE FORECASTS OF INSTRUMENT OPERATIONS AT AIRPORTS WITH FAA TRAFFIC CONTROL SERVICE (In millions) a/

	Total Aircraft		
	1987	1993	2005
FAA 1982 Forecast (Basis for FAA plan)	46.2	55.4	74.8
FAA 1983 Forecast	44.3 (-4.1)	52.9 (-4.5)	66.6 (-11.0)
Forecast Based on Maturity Scenario	40.4 (-12.6)	45.6 (-17.7)	52.9 (-29.3)

SOURCE: CBO from FAA data.

NOTE: Actual operations for 1982 were 31.6 millions.

a. Numbers in parentheses are the percent differences from the 1982 FAA forecast.

TABLE C-11. ALTERNATIVE FORECASTS OF AVIATION FUEL CONSUMPTION (In billions of gallons) a/

	Air Carrier			General Aviation			Total Aircraft a/		
	1987	1993	2005	1987	1993	2005	1987	1993	2005
FAA 1982 Forecast (Basis for FAA plan)	10.0	11.8	15.4 b/	1.9	2.8	4.1 b/	12.0	14.6	19.5 b/
FAA 1983 Forecast	9.4 (-6.0)	11.1 (-5.9)	14.2 b/ (-7.8)	1.9 (---)	2.6 (-7.1)	4.0 b/ (-2.4)	11.3 (-5.8)	13.7 (-6.2)	18.0 b/ (-7.7)
Forecast Based on Maturity	9.1 (-9.0)	10.0 (-15.3)	11.5 (-25.3)	1.7 (-10.5)	1.9 (-32.1)	2.1 (-48.8)	10.7 (-10.8)	11.8 (-19.2	13.6 (-30.3)

SOURCE: CBO from FAA data.

NOTES: Details may not add to totals because of rounding. Actual fuel consumption in 1982 was:

Total aircraft = 9.8 million
General aviation = 1.5 million
Air carrier = 8.3 million

a. Numbers in parentheses are the percent changes from the 1982 FAA forecast.
b. Extrapolated by Congressional Budget Office.

APPENDIX D. BACKGROUND ISSUES AND COMPUTATIONAL METHODS IN INVESTMENT APPRAISAL

BACKGROUND ISSUES

For long-lived capital investments, the simple rule that justifies adoption of a project--that benefits exceed costs--must be modified, since future benefits and costs are worth less than present ones. Indeed, the very existence of interest rates means that people do discount--attach less value--to future expenditures. Essentially, then, an investment is worthwhile if the sum of discounted benefits--their present value--exceeds the present value of its costs. 1/

Choice of Criteria

To compute the present values, an interest (or discount) rate must be selected. One approach would result in a rate (after inflation) of about 9 percent, representing the opportunity cost of capital in the private sector (on the basis of the observed real-dollar yield of 7 percent for corporate bonds, grossed up by approximately 30 percent to allow for the effective corporate profits tax). Others use a rate of about 5 percent to represent the real-dollar cost of federal government borrowing. Over the last few years, the Office of Management and Budget (OMB) has required the use of a 10 percent discount rate (after inflation) in federal investment appraisals. In other words, OMB would prefer to budget for only those capital projects that are likely to achieve a rate of return of 10 percent or more. Although this is a somewhat arbitrary policy, 2/ 10 percent happens to approximate fairly closely the estimated opportunity cost of capital in the private sector, although at present, it appears somewhat higher. Use of 10 percent as a test (or passmark) rate should thus guarantee that public investments do not supplant better investments that could be made by private firms.

---

1. See Ajit K. Dasgupta and D.W. Pearce, Cost-Benefit Analysis: Theory and Practice (MacMillan, 1972).

2. The fact that the OMB discount rate has remained unchanged since 1973 means that it is not geared to any particular market rate.

A way around the problem of estimating present values is to compute the FAA plan's internal rate of return directly, and then to compare this rate with a range of possible standards for federal investment (for example, 10 percent). As with the use of present values, it remains essential to choose some acceptable standard as the basis for comparison. The only advantage in computing the rates of return directly is that it conveys more precise information as to how close a project actually comes to the predetermined standard, and thus how risky the project is. [3]

COMPUTATIONAL METHODS

Chapter III presents four measures of cost-effectiveness of the FAA plan:

- Internal rate of return;
- Net present value;
- Benefit-to-Cost ratio;
- First-year benefit; and
- Risk analysis on the rate of return.

Rate of Return

The computational procedure to calculate the internal rate of return is based on the following definition:

> The internal rate of return is the discount rate that makes the net present value of a project equal to zero.

---

3. See David F. Bradford, "Constraints on Government Investment Opportunities and the Choice of Discount Rate," American Economic Review (December 1975).

This implies solving for the discount rate R the equation

$$\sum_{i=1}^{N} \frac{\sum_{j=1}^{NBS} Bi,j - \sum_{j=1}^{NCS} Ci,j}{(1 + 0.01R)^{i-1}} = 0$$

in which: NBS is the number of benefit streams
NCS is the number of cost streams
R is the discount rate expressed as a percentage
N is the life of the project (since the beginning of construction)
Ci, j is the i^{th} item, in the j^{th} cost stream
Bi, j is the i^{th} item, in the j^{th} benefit stream.

The above equation (a polynominal of $(N - 1)^{th}$ degree) is solved by successive approximations for the range -20 percent to 100 percent. 4/ The approach assumes the following:

(i) The net present value is a monotonic function of the discount rate; and

(ii) A federal project that merits appraisal will have an internal rate of return which will be in the range -20 percent to 100 percent.

Present Value

The present value is a discounting procedure performed over the set of current streams. The formula used is the following:

4. See The World Bank Group, Cost Benefit Package Users Manual (August 1979).

$$PV \sum_{i=1}^{N} \frac{\sum_{j=1}^{NBS} B_{i,j} - \sum_{j=1}^{NCS} C_{i,j}}{(1 + 0.01R)^{i-1}}$$

in which **R** is the OMB test rate of discount.

<u>Benefit-to-Cost Ratio</u>

The benefit-to-cost ratio is defined as the ratio, expressed as a decimal fraction, between the present value of total benefits and the present value of total costs of a project. The computational procedure uses all current streams (benefits and costs) and computes the following:

$$BCR = \frac{\sum_{i=1}^{N} \dfrac{\sum_{j=1}^{NBS} B_{i,j}}{(1 + 0.01R)^{i-1}}}{\sum_{i=1}^{N} \dfrac{\sum_{j=1}^{NCS} C_{i,j}}{(1 + 0.01R)^{i-1}}}$$

in which **R** is the OMB test rate of discount.

First-Year Benefit

The First-Year Benefit--often used as a test of the timing of a project--is the ratio, expressed as a percentage, between total benefits realized the first year after construction is completed, and total project costs. Interest on capital outlays during the construction period is computed and added to the total project cost; the equation used is the following:

$$FYB = \frac{\sum_{j=1}^{NBS} B_{kj}}{\sum_{i=1}^{k-1} \sum_{j \epsilon Jcc} Cij(1+0.01R)^{k-i-1}} * 100$$

in which **R** is the OMB test rate of discount.

Risk Analysis

A risk analysis amounts to repeated computations of the internal rate of return using, in each case, cost and benefit data that are modified by random variations expressed as a percentage of original values prior to each computation. The number of times the rate of return is computed determines the sample size. The sample generated is an artificial sample made on the basis of random patterns of variations (probability distributions) that, in CBO's judgment, reflect the real uncertainty of the cost and benefit estimates. The analysis also takes account of the dependency that might exist among uncertain streams.

All cost and benefit estimates are assumed to vary according to a normal probability distribution given by:

$$f(u_o) = \frac{1}{\sqrt{2 \Pi}} e^{-(1/2) u_o^2} \quad \text{for } -\infty < u_o < \infty$$

where:

$$E(u) = 0 \; ; \; \sigma_u^2 = 1$$

$$u = \frac{x_o - E(x)}{\sigma_x}$$

and

$$x_o = u_o \sigma_x + E(x)$$

APPENDIX E. TIME--VALUING AN INTANGIBLE

The dollar value of time to be saved by installation of the microwave landing system at the nation's airports is one of the least certain elements in any assessment of the FAA plan, including that in Chapter III. In essence, the problem boils down to: What would air travelers do with the time saved? Would they spend it on productive activity? Would that activity be recompensed and hence an economic factor? Or would people simply enjoy the relief from the irritation of wasting time? Related to these questions is the distinction--often not a clear one when travel is involved--between working time and leisure time.

Using empirical studies that indicate the value of time apparently used by air travelers, the FAA has placed the value of time savings at 100 percent of the average hourly earnings of all aviation users. 1/ Thus implicitly, the FAA regards time spent in transit as generally unproductive. Other analysts would take issue with this general approach, however. They would note, for example, that although roughly half of all air travel is done for business, many of those passengers spend a significant portion of their travel time engaged in work, often even in the same work that occasions the travel. In budgeting their workloads, many passengers actually count on airborne time as essential. Thus, time spent in transit may be far from wasted, and time absorbed by delays also not lost or wasted. According to this logic, then, the time savings attributable to the MLS could reasonably be valued at some fraction, but not the total rate, of passengers' earnings.

Another problem in arriving at a dollar value for time is the size of units of time saved. A span of ten minutes can quite easily be put to productive use, but ten one-minute savings are difficult to use. The time to be saved by the MLS is estimated roughly in the range of a few minutes per passenger per trip, and its economic value is therefore questionable.

A compromise approach would regard time spent in transit as not totally wasted and time saved as not totally productive in an economic sense. Analysts at the World Bank, for instance, have informally valued working time saved at about 50 percent of the average wage rate of all passengers, and nonworking time saved at about 25 percent of that rate.

---

1. House Committee on Appropriations, Hearings--Department of Transportation and Related Agencies Appropriations For 1984, 98:1 (1983).

What the World Bank uses for analytic purposes is an average of about 30 percent, weighted to reflect the proportions of work and leisure travel. This compromise assumption was used in the CBO's analysis.